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Touchless Hand Sanitizer Mobile Robot Application: Survey and Dataset Preparation for Deep Learning Recognition

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ABSTRACT

The COVID-19 pandemic spreads throughout the world, many sanitizer dispenser devices included robots designed to minimize human contact and as less as possible to minimize the speared of this pandemic or any germs among humans. In many positions, these sanitizers dispensers are important to sterilize and help people from infection such as patients and medical staff in hospitals, teachers, and students in schools or universities, etc. In this paper, many studies of sanitizer dispenser devices including mobile robot applications for touchless hand sanitizers especially in the coronavirus pandemic have been explained. The major aim of this survey is to compare and contrast many previous survey methodologies. This study covered the introduction to robot applications, hand sanitizers dispenser device including a mobile robot, and object detection-based deep learning techniques that recognizes people. Object detection with the deep learning method is discussed because it is the most important feature of the hand sanitizer device, which is based on a mobile robot application. Furthermore, in this work, the proposed block diagram of dataset processing has been instigated using the mini-computer Raspberry Pi version 4, Raspberry Pi camera system, and LabelImg graphical tool. These dataset outputs files of each image (label.xml and image.jpg) are prepared and classed into 7 classes to use as inputs to the next future work of deep learning. In future work, we want to create a mobile robot hand sanitizer that recognizes the people using a deep learning approach. The python programing language has been used. The contribution of this work is to create, annotate and prepare the dataset for Deep Learning while the previous related works depended on existing dataset that taken from website .

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1. Introduction

The mobile robot types based on raspberry pi are controlled remotely via the internet using for surveillance purposes [1]. A mobile robot can be defined as a robot that autonomously moves from one position to another position without any assistance from a human operator [2]. Three years ago, COVID-19, called SARS-Cov-2 (coronavirus) spreads all over the world. It was discovered in China country. The World Health Organization (WHO) considered coronavirus a pandemic. The infection of this virus fast increased and led to people's death. Human life's changed and also the interaction of persons in all places [3][4]. So, it is needed, to discover devices (robots) to less as possible speared COVID-19 in hospitals and other places such as hand sanitizer robots and other techniques [5]. Some of these techniques solutions are telepsychiatry, elemental healthcare services, virtual reality (VR), and robots used for delivery using AI including Deep Learning [6]. Deep learning is one of the highly demanded and very successful machine learning approaches that are based on artificial neural networks (ANN) used for feature selection. The ANNs are made of a set of arranged layered nodes. It consists of triple-layered nodes and input, one hiding layer, and exterior layered nodes [7][8][9]. COVID-19 feature selection (object detection) of the Deep Learning algorithm is the most feature important part because it detects objects such as rectangular bounding boxes for sick or normal people who want to sanitize their hands [10]. The main contribution of this work is to create, annotate and prepare the dataset for Deep Learning while the previous related works depended on existing dataset that taken from website .

2. Related Work of Touchless Hand Sanitizers

In the coronavirus pandemic, the virus spreads among people. One of the main techniques to avoid the virus is invitation hand sanitizers. For example, in the same place, the persons are sterling, and touching the same bottle of hand sanitizer increases the risk of contamination so it is needed to invite touchless hand sanitizers. In this section, many hand sanitizers device or robot techniques have been studied in two directions one direction is touchless hand sanitizers device without deep learning and the other direction is object detection using deep learning.

2.1. Touchless hand sanitizers device without deep learning:

• Lee et al. in 2020 [11], implemented a fixed automatic hand sanitizer device in two parts, one part named the instrument structure that contains the following hardware: DC motors, H-bridge for drive motors, breadboard, power supply, and IR sensor which located at the top of the hand sanitizer device. The second part called the control part includes the Arduino controller which is used to control the motor's motion. The device works when the IR sensor detects the person's hand, the motor operates and it opens the sanitizer and then pumped the liquid into the person's hand. The device is useful in the marketplace.

• Bana, in 2021 [12], studied Anthropomorphism phenomenon. It is a physical interaction of humans with objects in the environment. Depended on this phenomenon, the researchers compared two devices of hand sanitizer, one is a mobile robot and the other is a stick. The results have been observed that the number of

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passersby persons sanitizing their hands using mobile robots is more than the number of people who sanitized their hands using a stick on the university campus place. This is because the passersby person can interact with mobile robot sociality.

• Eddy et al., In 2020 [13], designed a contactless hand sanitizer robot dispenser system using the Internet of Things (IoT) depending on robotics technology. The hardware consists of IR (Infrared sensor), Arduino kit microcontroller, Ultrasonic sensor, Motors, Wheels, Bluetooth, LCD monitor, and GPS module. The hand sanitizer robot is used to hand sanitizer in public places.

• Abuga and Nyamweya, In 2021 [14], presented a review of Alcohol-based hand sanitizers (ABHS). The material components that go into its formulation have an impact on product qualities and performance, hence ABHS should be examined from a multidimensional perspective from the design level. To assure the safety and efficacy of ABHS products, it is critical to understand how these elements interact.

• Sathwara, Vaghela, and Joshi, in 2022 [15], implemented a contactless temperature measurement of a fixed hand sanitizer dispenser device called AROGYAKAVACHAM. It is beneficial in reducing COVID-19 transmission infection. The system is powered by a rechargeable DC battery that is charged using a solar panel. To save money and make the AROGYAKAVACHAM gadget more compact, it was connected to a 12V AC supply with a 1A converter. Along with the alleged temperature, the ambient temperature was measured. There are a few drawbacks to the device: 1- The gadget was required to record the temperature of anyone who entered the premises and sat 6 feet away from the AROGYAKAVACHAM equipment. 2-During operation, the system was unable to function due to low solar pane insolation. 3- A temperature sensor that cannot deliver a precise reading if the person's hands cannot be within the specified range, as well as a shaky reading.

• Edozie, Janat, Kalyankolo, and Systems, in 2020 [16], implemented a fixed hand sanitizer dispenser with a door controller deepened on the microcontroller called ATMEGA328P. In many confined places, such as schools or hospitals, a system aids security officers. However, unless a person first sanitizes his or her hands, the gates remain locked. An ultrasonic sensor checked for the presence of hands near the sanitizing system's output. It calculated the distance between itself and the sanitizer outlet and instructed ATMEGA328P microprocessor to operate the servo motor when the distance can less than 10 cm, allowing the sanitizer to be pushed out and the hands to be cleaned. The hand was spotted by the ultrasonic sensor. When the hand is detected, the first servo motor is activated, causing the liquid sanitizer to be poured onto the hand and the message to be shown on the LCD.

• Srihari, in 2020 [17], designed an automatic hand wash sanitizer system. When an IR sensor is detected, the motor pushes sanitizer liquid to the individual who wants to sterilize his hands. Three control Light-Emitting Diode (LED) with an Adaptor port were used in an automatic hand wash sanitizer: white LED (Working Mode), red LED (Battery Charging Mode), and green LED (Battery Charging Mode) (Battery Full Charged Mode). Although the sanitizer system is effective and inexpensive, it is a practical and permanent sanitize system.

• Hind Z. Khaleel, Firas A. Raheem, and Mahdi Azzam, in 2022 [18], constructed and deployed a mobile contactless hand sanitizer robot that detects the human body by capturing images from vision and calculating the distance between the person and robot. A microcontroller was used to drive 4 DC motors. It has been established that a mobile robot can make a suitable error to a person at any time. This design outperforms the traditional and manual touchless hand sanitizer designs.

2.2. Object Detection with Deep Learning:

• Girshick, Donahue, Darrell, and Malik, in 2014 [19],presented a scalable and simple object detection algorithm using deep learning called a region-based convolutional neural network(R-CNN) where the mean average precision (mAP) is more than 30% due to the previous PASCAL VOC 2012 dataset result. It has achieved a 53.3%. of mAP.

• Nasser et al., in 2021 [20], proposed a strategy based on cutting-edge software and hardware technology. A deep learning (DL) model based on artificial intelligence predicted glucose levels at 30 minutes intervals. Furthermore, Cloud computing and the Internet of Things (IoT) technologies are being examined for implementing a model of prediction and combining it with the wearable called Continuous glucose monitoring (CGM) model to offer patients future glucose level predictions. Because of its superior properties in terms of enhanced prediction accuracy. A cascaded model called RNN (Recurrent Neural Network)-RBM (Restricted Boltzmann) DL based on both recurrent neural networks. (RNNs) and restricted Boltzmann machines (RBM) has been considered among the numerous Deep Learning approaches in the state-of-the-art (SoTA). According to the findings of the experiments, the suggested Cloud and Deep Learning (DL) based wearable system obtains an average accuracy that equals 15.589 in terms of root mean square.

• Li, Cao, and Zhang, in 2020 [21], detected the face mask with object detection technique depending on deep learning using the You only look once (YOLOv3) deep learning algorithm. The number of images in the dataset is equal to 9886 images that have been taken from the WIDER FACE and MAFA datasets. These face mask datasets relabeled and classified using YOLOv3 with mAP reached 86.3%.

• Sachan, in 2019 [22], suggested a model that can classify the fruit's color and size using deep learning with a single shot detector (SSD) Lite model from the Tensorflow model zoo and OpenCV. Tensorflow model is a tool that enables a person to create their own image classifiers and OpenCV is Open-Source Computer Vision Library. It can be recognized the fruit if it is full-grown or not depending on its color. Object detection finds the difference between colors, and size to distinguish the count of fruits by using camera (webcams, Picams, etc.) and using a raspberry pi microcontroller. The model was useful in gardens and orchards. The programming language is python.

• S. UĞUZ, in 2020 [23], Developed a deep learning Single Shot Detector (SSD) framework for disease detection. Olive peacock spot is a plant disease, and the dataset samples 1460 olive leaves. During the spring and summer, samples were gathered from the Aegean region for Turkey. An average precision (AP) of 96 percent is achieved

• Abagiu, Popescu, Manta, and Popescu, in 2020 [24], built a mobile robot using OpenCV and the YOLO version three deep learning object detection methods. The mobile robot moved in the area either teleoperated by video from a tablet camera or independently. The independent recognition of items or people in the environment by a mobile robot. The accuracy of a specific person's hand was 82 percent. The writers' flaw was that they only recognized a specific person and a few objects, but not injured people or people who fell to the ground in perilous situations.

• Mahmoud, Nasser, in 2021 [25], based on the network's dual architectural architecture, provided a deep learning technique A multi-class network of convolutional neural networks (CNNs) was provided for the input data categorization. A Region-Based Convolutional Neural network called Faster R-CNN network with a modified Feature Pyramid Networks (FPN) network is used to improve the detection of microscopic objects, while the You Only Look Once version 3 (YOLOv3) structure is used to detect the objects.Each network can detect an object independently. Following that, the decision maps are combined and compared to see if an item is present. The YOLOv3 outperforms the quicker R-CNN with the FPN model in terms of mean average precision (mAP) and Intersection over Union (IoU).

• Liu et al., in 2016 [26], suggested a method for employing a single deep neural network to recognize item in pictures. SSD network discretizes the output bounding boxes into a series of default boxes with varying ratios and sizes. The SSD network intelligently handles objects of various sizes at prediction time by combining predictions from the feature of maps with different resolutions. The SSD is more straightforward than systems that rely on object proposals because it eliminates the requirement for proposal creation and subsequent pixel resampling by encapsulating and processing a single network. On an Nvidia Titan for 300 X 300 input, SSD gets 74.3 percent mAP on the VOC2007 test at 59 frames per second.

• Xu and Mao, in 2020 [27], addressed the issue of data privacy in the remote sensing data training process, researchers developed a software-based traffic congestion monitoring system as well as a federated learning approach for recognizing vehicle targets in remote sensing photographs. The experiment used the Los Angeles

Road and Washington Road remote sensing image data sets as training samples, and the training of results may attain an accuracy of over 85%, with an estimated processing time as low as 0.047 seconds per photo. According to the final trial findings, the system can automatically detect vehicle targets in remote sensing photographs to satisfy the purpose of identifying congestion.

• I. Ahmed, M. Ahmad, A. Ahmad, and G. Jeon, in 2021 [28], developed a deep learning-based IoT-based crowd surveillance system that recognizes and counts individuals using an overhead view viewpoint. The SSD model detects the person, with Mobilenetv2 as the base network. The detection model's accuracy is improved by using a transfer learning technique. The two virtual lines are established for counting the number of people leaving and entering the scenario. To assess performance, experiments with various video clips are carried out. Transfer learning is used to increase the performance system's overall detection to 95 percent.

• M. Tan, R. Pang, and Q. V. Le, in 2020 [29], proposed a weighted bi-directional feature pyramid network (BiFPN) of object detection, which enables the multi-scale feature of fusion. Furthermore, the authors, use a compound scaling way that scales the resolution, depth, and width of all backbone, feature network, and box-class prediction networks at the same time. They built a new family of object detectors named EfficientDet has more efficiency than prior research. EfficientDet D7 achieves state-of-the-art 52.2 AP on COCO with single-model and single-scale.

• López-Alfaro et al., in 2021 [30], designed a mobile robot that is used in the Internet of Things (IoT) structure and can be controlled remotely. The camera is attached to the mobile robot to find (object) images from a mobile robot. The commands have been stored in a web server in order to control the motion in MySQL database mobile robot in addition it is useful to the transmit the commands between the mobile robot and server via web pages with Android application and PHP and WiFi. The landscape (object) images deal with in a computer by python language and with YOLO structure. The landscape object image is classified into two classes: agave plants and stones. Accuracy reached 81.2%. the drawback is the mobile robot is controlled by an Android phone application and not autonomously.

3. Preparing, Creating and Processing Dataset.

In this work, Fig. 1 shows the proposed block diagram of the created dataset and processing described below:

1. The block 1 shows the capturing dataset images from the Raspberry Pi version 2.1 camera for more detail on this camera described in [31] with a mini-computer Raspberry Pi 4 system [32].

2. The block 2 shows the saved dataset that equals to 438 images were saved in a mini-computer Raspberry Pi 4, where, each image size is 1024X768.

3. Then, the block 3 shows the graphical image annotations (LabelImg) software has been written in Python language [33] uses to make a green rectangular bounding box of each object in order to make many classes. The output of each image file was saved and consisted of two files: one XML file in PASCAL VOC format, and the other, image.jpg. These two outputs file of each image from LabelImg software supports the deep learning algorithms. In this work, the 7 number of classes for object detection were created and classified into following:

[left_nearest_person, nearest_human, non_person, person_back,person_front,person_side,right_nearest_person]. These classes and all dataset creation are very useful in the next step of our work on deep neural network training.

Fig (1): The proposed block diagram of dataset processing.

4. Discussion

In this paper, the review of touchless hand sanitizer dispensers has been studied. Table 1. described the six main related works. These related works are compared according to sanitizer technology such as automatic or manual. Also, they are compared according to fixed or movable device sanitizer.

Table 1 - Compression of Hand Sanitizer

No.	Years	Author's Name	Reference	Fixed or movable device Sanitizer	Advantage	Sanitizer Technology
1	2020	J. Lee, J.-Y. Lee, S.-M. Cho, K.-C. Yoon, Y. J. Kim, and K. G. J. H. i. r. Kim.	[11]	Fixed device	hand sanitizer	automatic
2	2021	P. B. & D. H. Knight.	[12]	fixed (stick) and movable mobile robot	hand sanitizer	Automatic and manual
3	2020	Y. Eddy Mohammed, M. N, et al.	[13]	movable mobile robot	hand sanitizer	automatic
4	2022	H. Sathwara, P. Vaghela, and S. Joshi.	[15]	AROGYAKAVACH AM fixed device	hand sanitizer	automatic
5	2020	E.Edozie, W. Janat, et al.	[16]	fixed device	hand sanitizer	automatic
6	2020	M. M. Srihari	[17]	fixed device	hand sanitizer	automatic

On the other side, object detection with deep learning is explained because it is the main feature related to hand sanitizer devices including mobile robots. Furthermore; The proposed block diagram of dataset processing has been implemented using a mini-computer Raspberry Pi 4 and Raspberry Pi camera system and LabelImg python tool. This dataset output files of each image (label.xml and image.jpg) are prepared and classed in order to use them as inputs to deep learning in the next future work. In the future our work, the mobile robot hand sanitizer with a deep learning algorithm used for object detection.

5. Conclusion and Future Work

Three years ago, Coronavirus spreads around the world. Coronavirus has been classified as pandemic by the World Health Organization (WHO). The spread of this virus was rapid that caused many people to die as a result. Human life has changed, as has the way people interact in all areas. This paper presents the application of robots in all fields of life. Then it looks into the review of the touchless hand sanitizer dispensers. These touchless hand sanitizers have been compared based on whether they employed an automatic or manual sanitizer. They also compared whether the sanitizer is a stationary or movable device. Furthermore, the block diagram of 438 images of dataset processing has been proposed. This dataset outputs files of each image (label.xml and image.jpg) prepared and classed for seven classes in order to use them in next future work deep learning. In future work, the mobile robot of a hand sanitizing facility application will be trained by a deep learning algorithm then it will be detecting a person before performing its full function of sanitation. The contribution of this paper is to create, annotate and prepare the dataset for Deep Learning while the previous related works depended on existing dataset that taken from website .

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